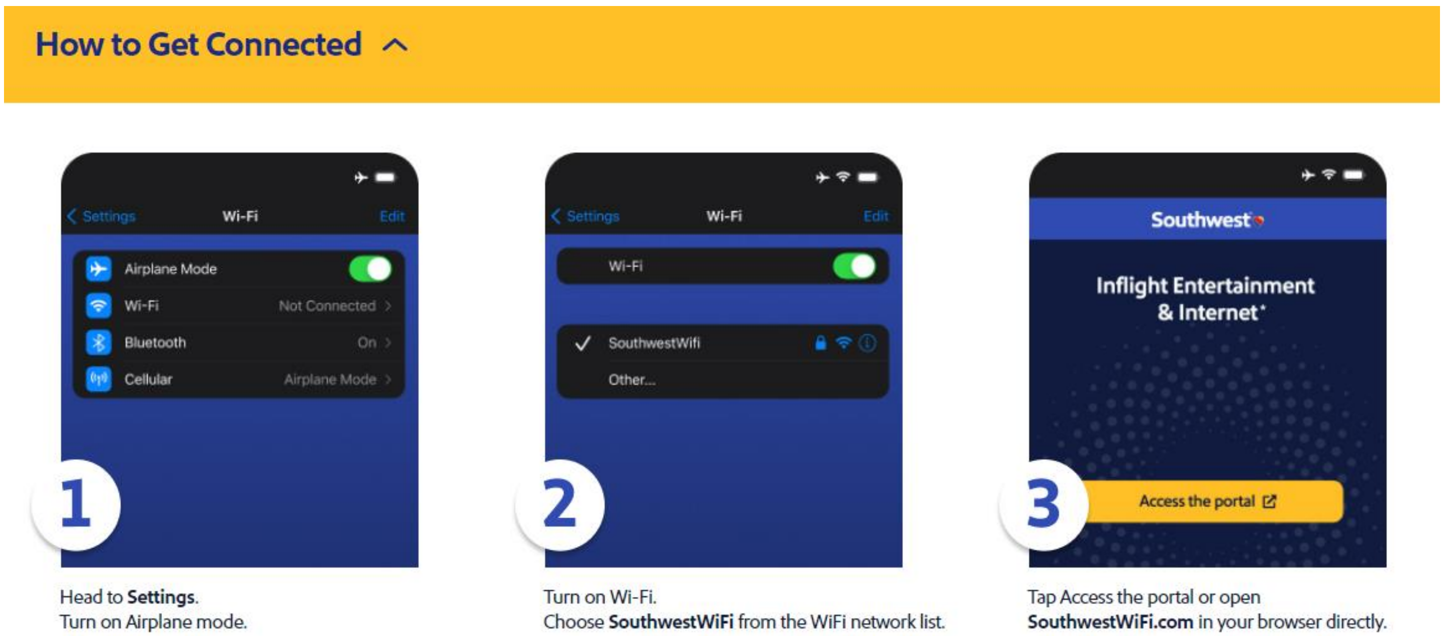
Exhibit 11 to Complaint
Intellectual Ventures I LLC and Intellectual Ventures II LLC

Example Southwest Count 4 Systems and Services
U.S. Patent No. 8,027,326 ("'326 Patent")

The Accused Systems and Services include without limitation Southwest systems and services that provide Wi-Fi Access Points that support at least IEEE 802.11n and/or 802.11ac; all past, current, and future systems and services that operate in the same or substantially similar manner as the specifically identified systems and services; and all past, current, and future Southwest systems and services that have the same or substantially similar features as the specifically identified systems and services ("Example Southwest Count 4 Systems and Services" or "Southwest Systems and Services").

On information and belief, the Southwest Systems and Services provide Wi-Fi Access Points that enable Internet connectivity on its airplanes.



Source: https://www.southwest.com/inflight-entertainment-portal/.[1]

[1] All sources cited in this document were publicly accessible as of the filing date of the Complaint.

We're excited to announce that as of yesterday, March 9, 2023, our first aircraft equipped with hardware from our new WiFi vendor, Viasat, has entered service. Viasat is an industry leader, and we're excited about the increased connectivity and reliability that Viasat will provide. As we prepare for additional Viasat-equipped aircraft deliveries, we're also making significant progress updating our existing fleet with new Anuvu hardware (our original WiFi vendor). We have now upgraded more than 400 aircraft and are well on our way to upgrading the entire fleet by the third quarter of this year.

Between our upgraded Anuvu hardware and integration of Viasat, we're bringing a faster, more reliable WiFi experience. In addition to improved WiFi quality, Viasat offers Customers the ability to trade paid internet connectivity between personal devices (known as "device swapping"). For example, if a Customer has paid for Internet using their laptop, they can use the "swap device" function in the Inflight Entertainment Portal to switch connectivity to their phone.

	Anuvu Legacy	**Anuvu Upgraded**	**Viasat**
Improved Speeds and Reliability	✗	✓	✓
Streaming (when authenticated for Internet)	✗	✓	✓
Device Swap	✗	✗	✓
Free Entertainment, Texting, and Flight Tracker	✓	✓	✓

Source: https://www.swamedia.com/southwest-stories/wifi-modernization-first-viasat-aircraft-enters-service-MC5XTXWTTLWNESJDQR4LZQBIDI2I.

On information and belief, Southwest uses routers that support WiFi 802.11 ac/abgn, such as the Viasat Select Router.

Viasat Select Router

Redefining the in-flight connectivity experience

The Viasat Select Router, coupled with Viasat's latest generation satellite terminal, delivers a fully managed internet connectivity network inside the cabin that promises to deliver maximum speed and capabilities from Viasat's high-capacity satellite network.

Source: https://www.viasat.com/content/dam/us-site/aviation/documents/Viasat_Select_Router-datasheet.pdf.

Multi-link connections

The Viasat Select Router ("VSR") is a fully featured cabin connectivity management device that integrates the Viasat connectivity service with other available cabin connectivity on the aircraft. User traffic is routed automatically over the best available network and in the event of a service disruption, an alternate service is automatically selected to ensure continuous internet access.

Every VSR is equipped with an integral cellular modem that enables near global 4G LTE data service while the aircraft is on the ground. The data service can be used by passengers or crew, and is available to Viasat's technical support team for remote access to assist with equipment configuration, software updates, and other troubleshooting support, while the aircraft remains in the hangar.

The router incorporates an 802.11ac Wi-Fi access point for easy in-cabin wireless connectivity for passengers, crew and ground operations. Additional antennas can be added to ensure optimal signal strength inside the cabin as necessary.

Source: https://www.viasat.com/content/dam/us-site/aviation/documents/Viasat_Select_Router-datasheet.pdf.

SPECIFICATIONS

Size	1.75 in. H × 7.8 in. W × 5.5 in. D	**Storage**	1 TB (OS and applications)
Weight	3.9 lbs	**Ethernet Ports**	› 5 x 10/100/1000 bps Ethernet Ports (Switched) › 1 x 10/100/1000 bps Ethernet Ports (Direct) › 1 x 10/100/1000 bps Ethernet Ports (Front Panel)
Voltage	28VDC with 200ms Hold-up	**ARINC 429**	2x Rx Channels / 1x Tx Channel
Power	20W(typical); 30W (max)	**Cellular Modem**	Integrated Global coverage 4G/LTE Advanced modem; 2x mini SIMs; 2x RF QMA connections
Environment	Qualified to DO-160G	**Wi-Fi**	802.11 ac/abgn; 3x RF QMA connections
Processor	Intel E3845 4 Core processor, 1.5GHz		

Source: https://www.viasat.com/content/dam/us-site/aviation/documents/Viasat_Select_Router-datasheet.pdf.

IEEE 802.11n™, or Wi-Fi 4, was introduced in 2009 to support the 2.4 GHz and 5GHz frequency bands, with up to 600 Mbit/s data rates, multiple channels within each frequency band, and other features. IEEE 802.11n data throughputs enabled the use of WLAN networks in place of wired networks, a significant feature enabling new use cases and reduced operational costs for end users and IT organizations.

IEEE 802.11ac™, or Wi-Fi 5, was introduced in 2013 to support data rates at up to 3.5 Gbit/s, with still-greater bandwidth, additional channels, better modulation, and other features. It was the first Wi-Fi standard to enable the use of multiple input/multiple output (MIMO) technology so that multiple antennas could be used on both sending and receiving devices to reduce errors and boost speed.

Source: https://standards.ieee.org/beyond-standards/the-evolution-of-wi-fi-technology-and-standards/.

On information and belief, other Southwest In-Flight Connectivity (IFC) providers, such as Anuvu, support IEEE 802.11n and 802.11ac.

Satellite-based Connectivity and Entertainment experience

- High-speed internet and content streaming
- Consistent connected service with optimized network coverage
- Tiered payment configuration
- Ancillary revenue models
- Entertainment delivered as fully licensed and industry compliant
- Line-fit and retro-fit installation options
- No-touch software and content updates
- Flying onboard over 1,000+ aircraft

Direct to passenger's own device connectivity and entertainment inflight experience

Source:
https://d1io3yog0oux5.cloudfront.net/anuvu/files/pages/anuvu/db/620/description/AirconnectGlobalKU_Final_ProductSheet+.pdf.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td>[1.pre] A method for increasing data rates and data throughput in a network, the method comprising:</td><td>
To the extent this preamble is limiting, on information and belief, the Southwest Count 4 Systems and Services practice a method for increasing data rates and data throughput in a network.
On information and belief, Southwest provides in flight Wi-Fi connectivity through provider equipment provided by Viasat and Anuvu. This equipment is compliant with Wi-Fi 802.11n and 802.11ac protocols. For example, the Viasat equipment and Anuvu equipment is compliant with the Wi-Fi 802.11n and 802.11ac protocols.
We're excited to announce that as of yesterday, March 9, 2023, our first aircraft equipped with hardware from our new WiFi vendor, Viasat, has entered service. Viasat is an industry leader, and we're excited about the increased connectivity and reliability that Viasat will provide. As we prepare for additional Viasat-equipped aircraft deliveries, we're also making significant progress updating our existing fleet with new Anuvu hardware (our original WiFi vendor). We have now upgraded more than 400 aircraft and are well on our way to upgrading the entire fleet by the third quarter of this year.
Between our upgraded Anuvu hardware and integration of Viasat, we're bringing a faster, more reliable WiFi experience. In addition to improved WiFi quality, Viasat offers Customers the ability to trade paid internet connectivity between personal devices (known as "device swapping"). For example, if a Customer has paid for Internet using their laptop, they can use the "swap device" function in the Inflight Entertainment Portal to switch connectivity to their phone.
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</table>
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Source: https://www.viasat.com/content/dam/us-site/aviation/documents/Viasat_Select_Router-datasheet.pdf.

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U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	Satellite-based Connectivity and Entertainment experience • High-speed internet and content streaming • Consistent connected service with optimized network coverage • Tiered payment configuration • Ancillary revenue models • Entertainment delivered as fully licensed and industry compliant • Line-fit and retro-fit installation options • No-touch software and content updates • Flying onboard over 1,000+ aircraft **Direct to passenger's own device connectivity and entertainment inflight experience**

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	 Source: https://d1io3yog0oux5.cloudfront.net/anuvu/files/pages/anuvu/db/620/description/AirconnectGlobalKU_Final_ProductSheet+.pdf. On information and belief, by bonding two 20 MHz channels together, the IEEE 802.11-2016 standard enables 40 MHz capable high throughput (HT) operation, which can support high data rates up to 600 Mb/s.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	3A. Definitions specific to IEEE 802.11 The following terms and definitions are specific to this standard and are not appropriate for inclusion in the *IEEE Standards Dictionary: Glossary of Terms & Definitions*.[1] **3A.1 20 MHz basic service set (BSS):** A BSS in which the Secondary Channel Offset field is set to SCN. **3A.2 20 MHz high-throughput (HT):** A Clause 20 transmission using FORMAT=HT_MF or HT_GF and CH_BANDWIDTH=HT_CBW20. **3A.3 20 MHz mask physical layer convergence procedure (PLCP) protocol data unit (PPDU):** A Clause 17 PPDU, a Clause 19 orthogonal frequency division multiplexing (OFDM) PPDU, or a Clause 20 20 MHz high-throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH set to HT_CBW20 and the CH_OFFSET parameter set to CH_OFF_20. The PPDU is transmitted using a 20 MHz transmit spectral mask defined in Clause 17, Clause 19, or Clause 20, respectively. **3A.4 20 MHz physical layer convergence procedure (PLCP) protocol data unit (PPDU):** A Clause 15 PPDU, Clause 17 PPDU, Clause 18 PPDU, Clause 19 orthogonal frequency division multiplexing (OFDM) PPDU, or Clause 20 20 MHz high-throughput (HT) PPDU with the TXVECTOR parameter CH_BANDWIDTH set to HT_CBW20.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	3A.5 20/40 MHz basic service set (BSS): A BSS in which the supported channel width of the access point (AP) or independent BSS (IBSS) dynamic frequency selection (DFS) owner (IDO) station (STA) is 20 MHz and 40 MHz (Channel Width field is set to 1) and the Secondary Channel Offset field is set to a value of SCA or SCB. **3A.6 40-MHz-capable (FC) high-throughput (HT) access point (AP):** An HT AP that included a value of 1 in the Supported Channel Width Set subfield (indicating its capability to operate on a 40 MHz channel) of its most recent transmission of a frame containing an HT Capabilities element. **3A.7 40-MHz-capable (FC) high-throughput (HT) access point (AP) 2G4:** An HT AP 2G4 that is also an FC HT AP. **3A.8 40-MHz-capable (FC) high-throughput (HT) access point (AP) 5G:** An HT AP 5G that is also an FC HT AP. **3A.9 40-MHz-capable (FC) high-throughput (HT) station (STA):** An HT STA that included a value of 1 in the Supported Channel Width Set subfield (indicating its capability to operate on a 40 MHz channel) of its most recent transmission of a frame containing an HT Capabilities element. **3A.10 40-MHz-capable (FC) high-throughput (HT) station (STA) 2G4:** An HT STA 2G4 that is also an FC HT STA. **3A.11 40-MHz-capable (FC) high-throughput (HT) station (STA) 5G:** An HT STA 5G that is also an FC HT STA. **3A.12 40 MHz high throughput (HT):** A Clause 20 transmission using FORMAT=HT_MF or HT_GF and CH_BANDWIDTH=HT_CBW40. Source: IEEE Standard 802.11n-2009 at 3-4.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	3.2 Definitions specific to IEEE Std 802.11 **20/40 MHz basic service set (BSS):** A BSS in which the supported channel width of the access point (AP) or dynamic frequency selection (DFS) owner (DO) station (STA) is 20 MHz and 40 MHz (Channel Width field is equal to 1) and the Secondary Channel Offset field is equal to a value of secondary channel above (SCA) or secondary channel below (SCB). **40-MHz-capable (40MC) high-throughput (HT) access point (AP):** An HT AP that included a value of 1 in the Supported Channel Width Set subfield (indicating its capability to operate on a 40 MHz channel) of its most recent transmission of a frame containing an HT Capabilities element. Source: IEEE Standard 802.11-2016 at 143.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
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<tr><td></td><td>
20. High Throughput (HT) PHY specification

20.1 Introduction

20.1.1 Introduction to the HT PHY

Clause 20 specifies the PHY entity for a high throughput (HT) orthogonal frequency division multiplexing (OFDM) system.

In addition to the requirements found in Clause 20, an HT STA shall be capable of transmitting and receiving frames that are compliant with the mandatory PHY specifications defined as follows:
— In Clause 17 when the HT STA is operating in a 20 MHz channel width in the 5 GHz band
— In Clause 18 and Clause 19 when the HT STA is operating in a 20 MHz channel width in the 2.4 GHz band

The HT PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to four spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using one to four spatial streams is defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (four spatial streams, 40 MHz bandwidth).

Source: IEEE Standard 802.11n-2009 at 247.

19. High-throughput (HT) PHY specification

19.1 Introduction

19.1.1 Introduction to the HT PHY
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**

	The HT PHY is based on the OFDM PHY defined in Clause 17, with extensibility up to four spatial streams, operating in 20 MHz bandwidth. Additionally, transmission using one to four spatial streams is defined for operation in 40 MHz bandwidth. These features are capable of supporting data rates up to 600 Mb/s (four spatial streams, 40 MHz bandwidth).
	
	Source: IEEE Standard 802.11-2016 at 2334.
	
	40MHZ OFDM 802.11N
	
	• 802.11n also introduced a 40 MHz channel, which combined two 20 MHz channels
	• The 40 MHz channel consists of 128 subcarriers:
	  • 128 subcarriers:
	    • 108 transmit data subcarriers
	    • 6 as pilot carriers
	    • 14 unused

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	• When two 20 MHz HT channels are bonded together, some of the formerly unused subcarriers at the bottom of the higher channel and at the top end of the lower channel are able to be used to transmit data. • That is why the number of subcarriers is slightly more than two times the 56 subcarriers in a 20 MHz channel. • Each bonded channel consists of a primary and secondary 20 MHz channel. • The channels must be adjacent. A positive or negative offset indicates whether the secondary channel is the channel above or the channel below the primary channel. This is pictured in Figure 19.4. Source: https://dot11ap.wordpress.com/ht-channel-width-operation/. On information and belief, IEEE 802.11ac infringes for the same reasons as 802.11n. *See supra*. *See also*:

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	4.3.14 Very high throughput (VHT) STA The IEEE 802.11 VHT STA operates in frequency bands below 6 GHz excluding the 2.4 GHz band. A VHT STA is an HT STA that, in addition to features supported as an HT STA, supports VHT features identified in Clause 9, Clause 10, Clause 11, Clause 14, Clause 17, and Clause 21. The main PHY features in a VHT STA that are not present in an HT STA are the following: — Mandatory support for 40 MHz and 80 MHz channel widths — Mandatory support for VHT single-user (SU) PPDUs — Optional support for 160 MHz and 80+80 MHz channel widths — Optional support for VHT sounding protocol to support beamforming — Optional support for VHT multi-user (MU) PPDUs — Optional support for VHT-MCSs 8 and 9 Source: IEEE Standard 802.11-2016 at 197.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	Table 21-38—VHT-MCSs for mandatory 40 MHz, N_{SS} = 1 (table below)
	See also IEEE Standard 802.11-2016 at 2612, where a 40 MHz Modulation and Coding Scheme (MCS) is mandatory.

Table 21-38—VHT-MCSs for mandatory 40 MHz, N_{SS} = 1

VHT-MCS Index	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s) 800 ns GI	Data rate (Mb/s) 400 ns GI (See NOTE)
0	BPSK	1/2	1	108	6	108	54	1	13.5	15.0
1	QPSK	1/2	2	108	6	216	108	1	27.0	30.0
2	QPSK	3/4	2	108	6	216	162	1	40.5	45.0
3	16-QAM	1/2	4	108	6	432	216	1	54.0	60.0
4	16-QAM	3/4	4	108	6	432	324	1	81.0	90.0
5	64-QAM	2/3	6	108	6	648	432	1	108.0	120.0
6	64-QAM	3/4	6	108	6	648	486	1	121.5	135.0
7	64-QAM	5/6	6	108	6	648	540	1	135.0	150.0
8	256-QAM	3/4	8	108	6	864	648	1	162.0	180.0
9	256-QAM	5/6	8	108	6	864	720	1	180.0	200.0

NOTE—Support of 400 ns GI is optional on transmit and receive.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>
Table 21-46—VHT-MCSs for mandatory 80 MHz, N_{SS} = 1
<table>
<tr><th rowspan="2">VHT-MCS Index</th><th rowspan="2">Modulation</th><th rowspan="2">R</th><th rowspan="2">N_{BPSCS}</th><th rowspan="2">N_{SD}</th><th rowspan="2">N_{SP}</th><th rowspan="2">N_{CBPS}</th><th rowspan="2">N_{DBPS}</th><th rowspan="2">N_{ES}</th><th colspan="2">Data rate (Mb/s)</th></tr>
<tr><th>800 ns GI</th><th>400 ns GI (See NOTE)</th></tr>
<tr><td>0</td><td>BPSK</td><td>1/2</td><td>1</td><td>234</td><td>8</td><td>234</td><td>117</td><td>1</td><td>29.3</td><td>32.5</td></tr>
<tr><td>1</td><td>QPSK</td><td>1/2</td><td>2</td><td>234</td><td>8</td><td>468</td><td>234</td><td>1</td><td>58.5</td><td>65.0</td></tr>
<tr><td>2</td><td>QPSK</td><td>3/4</td><td>2</td><td>234</td><td>8</td><td>468</td><td>351</td><td>1</td><td>87.8</td><td>97.5</td></tr>
<tr><td>3</td><td>16-QAM</td><td>1/2</td><td>4</td><td>234</td><td>8</td><td>936</td><td>468</td><td>1</td><td>117.0</td><td>130.0</td></tr>
<tr><td>4</td><td>16-QAM</td><td>3/4</td><td>4</td><td>234</td><td>8</td><td>936</td><td>702</td><td>1</td><td>175.5</td><td>195.0</td></tr>
<tr><td>5</td><td>64-QAM</td><td>2/3</td><td>6</td><td>234</td><td>8</td><td>1404</td><td>936</td><td>1</td><td>234.0</td><td>260.0</td></tr>
<tr><td>6</td><td>64-QAM</td><td>3/4</td><td>6</td><td>234</td><td>8</td><td>1404</td><td>1053</td><td>1</td><td>263.3</td><td>292.5</td></tr>
<tr><td>7</td><td>64-QAM</td><td>5/6</td><td>6</td><td>234</td><td>8</td><td>1404</td><td>1170</td><td>1</td><td>292.5</td><td>325.0</td></tr>
<tr><td>8</td><td>256-QAM</td><td>3/4</td><td>8</td><td>234</td><td>8</td><td>1872</td><td>1404</td><td>1</td><td>351.0</td><td>390.0</td></tr>
<tr><td>9</td><td>256-QAM</td><td>5/6</td><td>8</td><td>234</td><td>8</td><td>1872</td><td>1560</td><td>1</td><td>390.0</td><td>433.3</td></tr>
<tr><td colspan="11">NOTE—Support of 400 ns GI is optional on transmit and receive.</td></tr>
</table>
See also IEEE Standard 802.11-2016 at 2616, where an 80 MHz Modulation and Coding Scheme (MCS) is mandatory.
</td></tr>
<tr><td>[1.a] selecting at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without</td><td>On information and belief, the Southwest Count 4 Systems and Services practice selecting at least a first channel and a second channel, wherein the first channel and the second channel are adjacent without any other channels therebetween, wherein the first channel and the second channel each have a plurality of data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers</td></tr>
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U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
any other channels therebetween, wherein the first channel and the second channel each have a plurality of data subcarriers, wherein the data subcarriers of the first channel and the data subcarriers of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels;	of the second channel are separated by a frequency gap corresponding to one or more guard bands between the first and second channels. On information and belief, an IEEE 802.11-2016 HT STA selects a Primary Channel and a Secondary Channel as indicated via the HT Operation element. **3. Definitions** **3.242 primary channel:** The common channel of operation for all stations (STAs) that are members of the basic service set (BSS). **3A.61 secondary channel:** A 20 MHz channel associated with a primary channel used by high-throughput (HT) stations (STAs) for the purpose of creating a 40 MHz channel. Source: IEEE Standard 802.11n-2009 at 2, 7. **3.2 Definitions specific to IEEE Std 802.11** **primary 20 MHz channel:** In a 40 MHz, 80 MHz, 160 MHz, or 80+80 MHz very high throughput (VHT) basic service set (BSS), the 20 MHz channel that is used to transmit 20 MHz physical layer (PHY) protocol data units (PPDUs). In a VHT BSS, the primary 20 MHz channel is also the primary channel.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	secondary 20 MHz channel: In a 40 MHz very high throughput (VHT) basic service set (BSS), the 20 MHz channel adjacent to the primary 20 MHz channel that together form the 40 MHz channel of the 40 MHz VHT BSS. In an 80 MHz VHT BSS, the 20 MHz channel adjacent to the primary 20 MHz channel that together form the primary 40 MHz channel of the 80 MHz VHT BSS. In a 160 MHz or 80+80 MHz VHT BSS, the 20 MHz channel adjacent to the primary 20 MHz channel that together form the primary 40 MHz channel of the 160 MHz or 80+80 MHz VHT BSS. In a VHT BSS, the secondary 20 MHz channel is also the secondary channel. **secondary channel:** A 20 MHz channel associated with a primary channel used by high-throughput (HT) stations (STAs) for the purpose of creating a 40 MHz channel or used by very high throughput (VHT) STAs for the purpose of creating the primary 40 MHz channel. Source: IEEE Standard 802.11-2016 at 161-63.

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7.3.2.57 HT Operation element

The operation of HT STAs in the BSS is controlled by the HT Operation element. The structure of this element is defined in Figure 7-95o24.

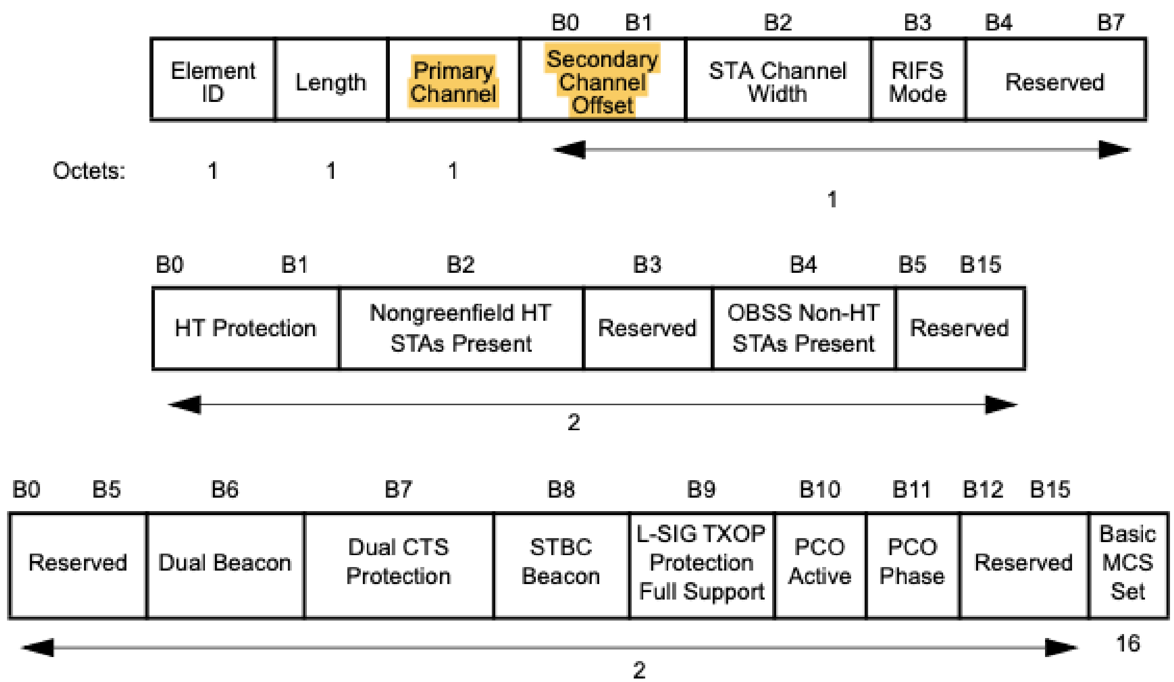


Figure 7-95o24—HT Operation element format

Source: IEEE Standard 802.11n-2009 at 76.

</td></tr>
</table>

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>
9.4.2.57 HT Operation element

The operation of HT STAs in the BSS is controlled by the HT Operation element. The structure of this element is defined in Figure 9-338.

<table>
<tr><th></th><th>Element ID</th><th>Length</th><th>Primary Channel</th><th>HT Operation Information</th><th>Basic HT-MCS Set</th></tr>
<tr><td>Octets:</td><td>1</td><td>1</td><td>1</td><td>5</td><td>16</td></tr>
</table>
Figure 9-338—HT Operation element format

Source: IEEE Standard 802.11-2016 at 950.

The structure of the HT Operation Information field is shown in Figure 9-339.

<table>
<tr><th></th><th>B0 B1</th><th>B2</th><th>B3</th><th>B4 B7</th></tr>
<tr><td></td><td>Secondary Channel Offset</td><td>STA Channel Width</td><td>RIFS Mode</td><td>Reserved</td></tr>
<tr><td>Bits:</td><td>2</td><td>1</td><td>1</td><td>4</td></tr>
</table>

Source: IEEE Standard 802.11-2016 at 951.
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	The fields of the HT Operation element are defined in Table 7-43p. The "Reserved in IBSS?" column indicates whether each field is reserved (Y) or not reserved (N) when this element is present in a frame transmitted within an IBSS.

Table 7-43p—HT Operation element

Field	Definition	Encoding	Reserved in IBSS ?
Primary Channel	Indicates the channel number of the primary channel. See 11.14.2.	Channel number of the primary channel	N
Secondary Channel Offset	Indicates the offset of the secondary channel relative to the primary channel.	Set to 1 (SCA) if the secondary channel is above the primary channel Set to 3 (SCB) if the secondary channel is below the primary channel Set to 0 (SCN) if no secondary channel is present The value 2 is reserved	N

Source: IEEE Standard 802.11n-2009 at 77.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>
Figure 9-339—HT Operation Information field

The Primary Channel field, subfields of the HT Operation Information field, and the Basic HT-MCS Set field are defined in Table 9-168. The “Reserved in IBSS?” column indicates whether each field is reserved (Y) or not reserved (N) when this element is present in a frame transmitted within an IBSS. The “Reserved in MBSS?” column indicates whether each field is reserved (Y) or not reserved (N) when this element is present in a frame transmitted within an MBSS.

Table 9-168—HT Operation element fields and subfields

<table>
<tr><th>Field</th><th>Definition</th><th>Encoding</th><th>Reserved in IBSS?</th><th>Reserved in MBSS?</th></tr>
<tr><td>Primary Channel</td><td>Indicates the channel number of the primary channel.
See 11.16.2.</td><td>Channel number of the primary channel</td><td>N</td><td>N</td></tr>
<tr><td>Secondary Channel Offset</td><td>Indicates the offset of the secondary channel relative to the primary channel.</td><td>Set to 1 (SCA) if the secondary channel is above the primary channel
Set to 3 (SCB) if the secondary channel is below the primary channel
Set to 0 (SCN) if no secondary channel is present

The value 2 is reserved</td><td>N</td><td>N</td></tr>
</table>

Source: IEEE Standard 802.11-2016 at 951.
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	Table 20-5—Timing-related constants

Parameter	TXVECTOR CH_BANDWIDTH			
	NON_HT_CBW20	HT_CBW_20	HT_CBW40 or NON_HT_CBW40	
			HT format	MCS 32 and non-HT duplicate
N_{SD}: Number of complex data numbers	48	52	108	48
N_{SP}: Number of pilot values	4	4	6	4
N_{ST}: Total number of subcarriers See NOTE 1	52	56	114	104

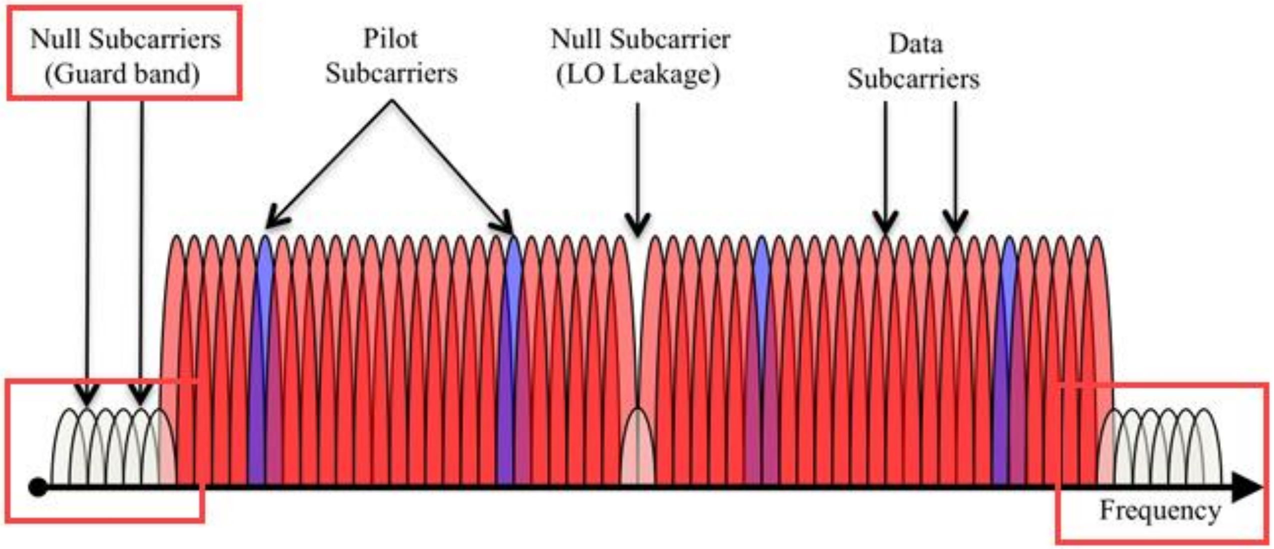
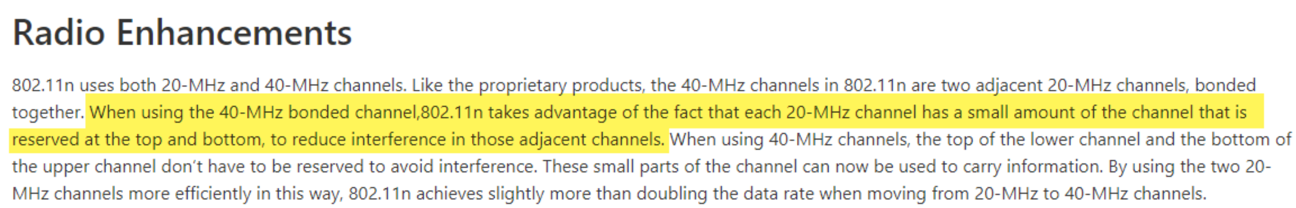
Source: IEEE Standard 802.11n-2009 at Table 20-5.

Table 19-6—Timing-related constants

Parameter	TXVECTOR CH_BANDWIDTH			
	NON_HT_CBW20	HT_CBW_20	HT_CBW40 or NON_HT_CBW40	
			HT format	MCS 32 and non-HT duplicate
N_{SD}: Number of complex data numbers	48	52	108	48
N_{SP}: Number of pilot values	4	4	6	4

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**

	Source: IEEE Standard 802.11-2016 at Table 19-6.
	
	40MHZ OFDM 802.11N
	
	• 802.11n also introduced a 40 MHz channel, which combined two 20 MHz channels
	• The 40 MHz channel consists of 128 subcarriers:
	  • 128 subcarriers:
	    • 108 transmit data subcarriers
	    • 6 as pilot carriers
	    • 14 unused
	
	• When two 20 MHz HT channels are bonded together, some of the formerly unused subcarriers at the bottom of the higher channel and at the top end of the lower channel are able to be used to transmit data.
	• That is why the number of subcarriers is slightly more than two times the 56 subcarriers in a 20 MHz channel.
	• Each bonded channel consists of a primary and secondary 20 MHz channel.
	• The channels must be adjacent. A positive or negative offset indicates whether the secondary channel is the channel above or the channel below the primary channel. This is pictured in Figure 19.4.
	
	Source: https://dot11ap.wordpress.com/ht-channel-width-operation/.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	 ***Figure 2.6. OFDM Subcarriers in the Frequency Domain.*** Source: http://download.ni.com/evaluation/rf/Introduction_to_WLAN_Testing.pdf.  Radio Enhancements 802.11n uses both 20-MHz and 40-MHz channels. Like the proprietary products, the 40-MHz channels in 802.11n are two adjacent 20-MHz channels, bonded together. When using the 40-MHz bonded channel,802.11n takes advantage of the fact that each 20-MHz channel has a small amount of the channel that is reserved at the top and bottom, to reduce interference in those adjacent channels. When using 40-MHz channels, the top of the lower channel and the bottom of the upper channel don't have to be reserved to avoid interference. These small parts of the channel can now be used to carry information. By using the two 20-MHz channels more efficiently in this way, 802.11n achieves slightly more than doubling the data rate when moving from 20-MHz to 40-MHz channels. Source: https://vocal.com/networking/ieee-802-11n/.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>
Channel Bonding

Channel bonding is used in 802.11n to bind two 20 MHz channels, to make one 40 MHz channel. Doubling the frequency space doubles the bandwidth, and doubling the bandwidth doubles the throughput. We can make an analogy with a highway. Moving from a two lines highway to a four lines highway doubles the traffic capacity. Same result applies in network. While 802.11a and g used 20 MHz channels, 802.11n uses 40MHz channels, thanks to Channel Bonding (see the following figure).

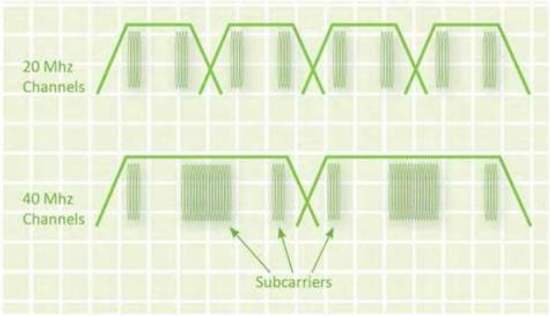
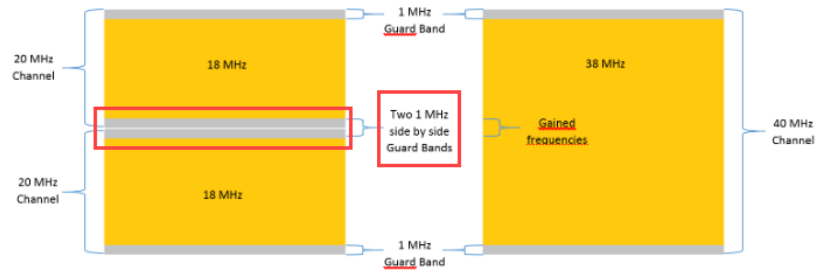


Figure 8: Channel Bonding

Source: https://www.gta.ufrj.br/ensino/eel879/trabalhos_vf_2014_2/remi/Physical%20Layer%20Improvements.html.
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	In fact, channel bounding more than doubles the throughput. One 20 MHz channel is composed of two 1 MHz channels, one at the beginning of the channel and one at the end, called Guard Bands. The 18 MHz left are used for data transfers. When using Channel Bonding, the two Guard Bands between two 20 MHz channels can now be used carry information.  Figure 9: Gained frequencies from previous Gard Bands when using Channel Bonding Source: https://www.gta.ufrj.br/ensino/eel879/trabalhos_vf_2014_2/remi/Physical%20Layer%20Improvements.html.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>
20.3.11.10.3 Transmission in 40 MHz HT format

For 40 MHz HT transmissions, the signal from transmit chain i_{TX} shall be as shown in Equation (20-59).

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} ([Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k, i_{STS}, n} + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \cdot \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}})) \qquad (20\text{-}59)$$
 301
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	where z is 3 in an HT-mixed format packet and 2 in an HT-greenfield format packet p_n is defined in 17.3.5.9 $$\tilde{D}_{k,\,i_{STS},\,n} = \begin{cases} 0, k = 0, \pm 1, \pm 11, \pm 25, \pm 53 \\ \tilde{d}_{M^r(k),\,i_{STS},\,n}, \text{otherwise} \end{cases}$$ $$M^r(k) = \begin{cases} k+58, -58 \le k \le -54 \\ k+57, -52 \le k \le -26 \\ k+56, -24 \le k \le -12 \\ k+55, -10 \le k \le -2 \\ k+52, 2 \le k \le 10 \\ k+51, 12 \le k \le 24 \\ k+50, 26 \le k \le 52 \\ k+49, 54 \le k \le 58 \end{cases}$$ $P^k_{(i_{STS},\,n)}$ is defined in Equation (20-55) NOTE—The 90º rotation that is applied to the upper part of the 40 MHz channel is applied in the same way to the HT-STF, HT-LTF, and HT-SIG. The rotation applies to both pilots and the data in the upper part of the 40 MHz channel. Source: IEEE Standard 802.11n-2009 at 301-302.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	Grouping is a method that reduces the size of the CSI Report field by reporting a single value for each group of *Ng* adjacent subcarriers. With grouping, the size of the CSI Report field is $Nr \times 8 + Ns \times (3 + 2 \times Nb \times Nc \times Nr)$ bits, where the number of subcarriers sent, *Ns*, is a function of *Ng* and whether matrices for 40 MHz or 20 MHz are sent. The value of *Ns* and the specific carriers for which matrices are sent are shown in Table 7-25f. If the size of the CSI Report field is not an integral multiple of 8 bits, up to 7 zeros are appended to the end of the report to make its size an integral multiple of 8 bits. **Table 7-25f—Number of matrices and carrier grouping** (table below) Source: IEEE Standard 802.11n-2009 at 50. On information and belief, IEEE 802.11ac infringes for the same reasons as 802.11n. *See supra*. *See also*:

BW	Grouping *Ng*	*Ns*	Carriers for which matrices are sent
20 MHz	1	56	All data and pilot carriers: –28, –27,…–2, –1, 1, 2,…27, 28
	2	30	–28,–26,–24,–22,–20,–18,–16,–14,–12,–10,–8,–6,–4,–2,–1, 1,3,5,7,9,11,13,15,17,19,21,23,25,27,28
	4	16	–28,–24,–20,–16,–12,–8,–4,–1,1,5,9,13,17,21,25,28
40 MHz	1	114	All data and pilot carriers: –58, –57, …, –3, –2, 2, 3,…, 57, 58
	2	58	–58,–56,–54,–52,–50,–48,–46,–44,–42,–40,–38,–36,–34,–32,–30, –28,–26,–24,–22,–20,–18,–16,–14,–12,–10,–8,–6,–4,–2, 2,4,6,8,10,12,14,16,18,20,22,24,26,28, 30,32,34,36,38,40,42,44,46,48,50,52,54,56,58
	4	30	–58,–54,–50,–46,–42,–38,–34,–30,–26,–22,–18,–14,–10,–6, –2, 2,6,10,14,18,22,26,30,34,38,42,46,50,54,58

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	19.3.11.11.4 Transmission in 40 MHz HT format For 40 MHz HT transmissions, the signal from transmit chain i_{TX} shall be as shown in Equation (19-59). $r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} ([Q_k]_{i_{TX}, i_{STS}}(\tilde{D}_{k, i_{STS}, n} + p_{n+z} P_{(i_{STS}, n)}^{k}) \Upsilon_k \cdot \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))$ (19-59) where z is 3 in an HT-mixed format packet and 2 in an HT-greenfield format packet p_n is defined in 17.3.5.10

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	$$\tilde{D}_{k,\, i_{STS},\, n} = \begin{cases} 0, k = 0, \pm 1, \pm 11, \pm 25, \pm 53 \\ \tilde{d}_{M^r(k),\, i_{STS},\, n}, \text{ otherwise} \end{cases}$$ $$M^r(k) = \begin{cases} k + 58, -58 \le k \le -54 \\ k + 57, -52 \le k \le -26 \\ k + 56, -24 \le k \le -12 \\ k + 55, -10 \le k \le -2 \\ k + 52, 2 \le k \le 10 \\ k + 51, 12 \le k \le 24 \\ k + 50, 26 \le k \le 52 \\ k + 49, 54 \le k \le 58 \end{cases}$$ $P^k_{(i_{STS},\, n)}$ is defined in Equation (19-55) NOTE—The 90° rotation that is applied to the upper part of the 40 MHz channel is applied in the same way to the HT-STF, HT-LTF, and HT-SIG. The rotation applies to both pilots and the data in the upper part of the 40 MHz channel. Source: IEEE Standard 802.11-2016 at 2390-2391.

Table 9-70—Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back

Channel Width	*Ng*	*Ns*	Subcarriers for which Compressed Feedback Beamforming Matrix subfield is sent: *scidx*(0), *scidx*(1), …, *scidx*(*Ns*-1)
20 MHz	1	52	–28, –27, –26, –25, –24, –23, –22, –20, –19, –18, –17, –16, –15, –14, –13, –12, –11, –10, –9, –8, –6, –5, –4, –3, –2, –1, 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28 NOTE—Pilot subcarriers (±21, ±7) and DC subcarrier (0) are skipped
	2	30	–28, –26, –24, –22, –20, –18, –16, –14, –12, –10, –8, –6, –4, –2, –1, 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
	4	16	–28, –24, –20, –16, –12, –8, –4, –1, 1, 4, 8, 12, 16, 20, 24, 28
40 MHz	1	108	–58, –57, –56, –55, –54, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –39, –38, –37, –36, –35, –34, –33, –32, –31, –30, –29, –28, –27, –26, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 54, 55, 56, 57, 58 NOTE—Pilot subcarriers (±53, ±25, ±11) and DC subcarriers (0, ±1) are skipped.
	2	58	–58, –56, –54, –52, –50, –48, –46, –44, –42, –40, –38, –36, –34, –32, –30, –28, –26, –24, -22, –20, –18, –16, –14, –12, –10, –8, –6, –4,–2, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58
	4	30	–58, –54, –50, –46, –42, –38, –34, –30, –26, –22, –18, –14, –10, –6,–2, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58
80 MHz	1	234	–122, –121, –120, –119, –118, –117, –116, –115, –114, –113, –112, –111, –110, –109, –108, –107, –106, –105, –104, –102, –101, –100, –99, –98, –97, –96, –95, –94, –93, –92, –91, –90, –89, –88, –87, –86, –85, –84, –83, –82, –81, –80, –79, –78, –77, –76, –74, –73, –72, –71, –70, –69, –68, –67, –66, –65, –64, –63, –62, –61, –60, –59, –58, –57, –56, –55, –54, –53, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –38, –37, –36, –35, –34, –33, –32, –31, –30, –29, –28, –27, –26, –25, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122 NOTE—Pilot subcarriers (±103, ±75, ±39, ±11) and DC subcarriers (0, ±1) are skipped.

Source: IEEE Standard 802.11-2016 at 768.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	(table below)

EXPANSION_MAT_TYPE	FORMAT is VHT and EXPANSION_MAT is present.	Set to COMPRESSED_SV	Y	N
	Otherwise	See corresponding entry in Table 19-1		
EXPANSION_MAT	FORMAT is VHT	Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 21.3.11.2 based on the channel measured during the training symbols of a previous VHT NDP PPDU.	MU	N
	Otherwise	See corresponding entry in Table 19-1		

Source: IEEE Standard 802.11-2016 at 2501.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	4.3.14 Very high throughput (VHT) STA The IEEE 802.11 VHT STA operates in frequency bands below 6 GHz excluding the 2.4 GHz band. A VHT STA is an HT STA that, in addition to features supported as an HT STA, supports VHT features identified in Clause 9, Clause 10, Clause 11, Clause 14, Clause 17, and Clause 21. The main PHY features in a VHT STA that are not present in an HT STA are the following: — Mandatory support for 40 MHz and 80 MHz channel widths — Mandatory support for VHT single-user (SU) PPDUs — Optional support for 160 MHz and 80+80 MHz channel widths — Optional support for VHT sounding protocol to support beamforming — Optional support for VHT multi-user (MU) PPDUs — Optional support for VHT-MCSs 8 and 9 Source: IEEE Standard 802.11-2016 at 197.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>

Table 21-38—VHT-MCSs for mandatory 40 MHz, N_{SS} = 1

VHT-MCS Index	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s)	
									800 ns GI	400 ns GI (See NOTE)
0	BPSK	1/2	1	108	6	108	54	1	13.5	15.0
1	QPSK	1/2	2	108	6	216	108	1	27.0	30.0
2	QPSK	3/4	2	108	6	216	162	1	40.5	45.0
3	16-QAM	1/2	4	108	6	432	216	1	54.0	60.0
4	16-QAM	3/4	4	108	6	432	324	1	81.0	90.0
5	64-QAM	2/3	6	108	6	648	432	1	108.0	120.0
6	64-QAM	3/4	6	108	6	648	486	1	121.5	135.0
7	64-QAM	5/6	6	108	6	648	540	1	135.0	150.0
8	256-QAM	3/4	8	108	6	864	648	1	162.0	180.0
9	256-QAM	5/6	8	108	6	864	720	1	180.0	200.0
NOTE—Support of 400 ns GI is optional on transmit and receive.										

See also IEEE Standard 802.11-2016 at 2612, where a 40 MHz Modulation and Coding Scheme (MCS) is mandatory.

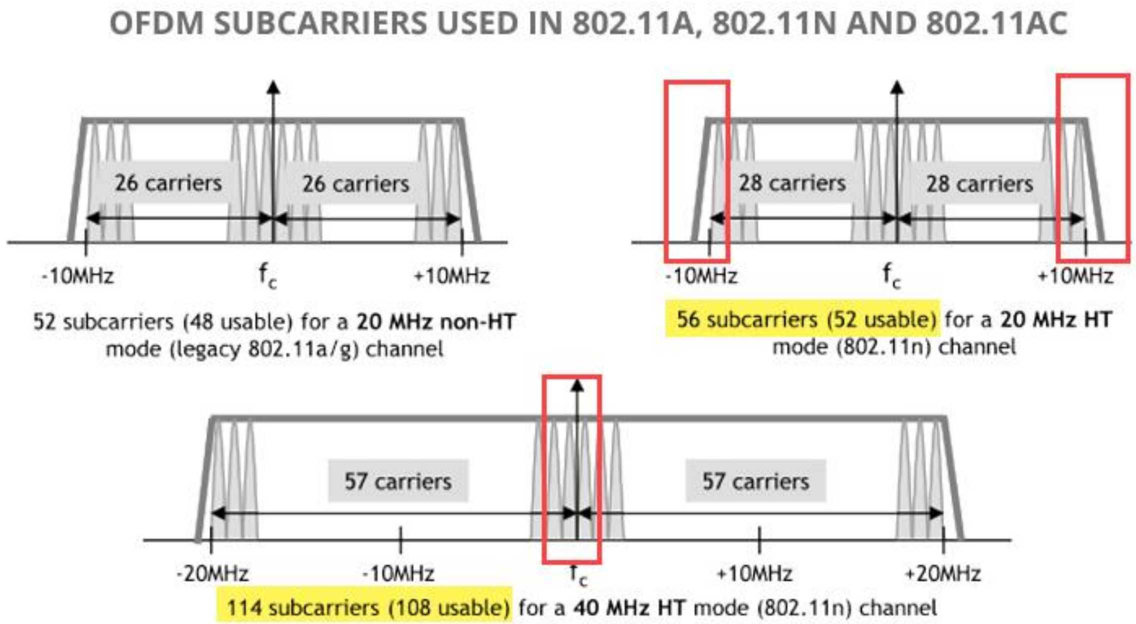
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	Table 21-46—VHT-MCSs for mandatory 80 MHz, N_{SS} = 1 (table below) See also IEEE Standard 802.11-2016 at 2616, where an 80 MHz Modulation and Coding Scheme (MCS) is mandatory.
[1.b] partially filling the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the	On information and belief, the Southwest Count 4 Systems and Services practice partially filling the frequency gap between the first channel and the second channel by adding one or more data subcarriers into the frequency gap such that the one or more guard bands are at least partially filled

Table 21-46—VHT-MCSs for mandatory 80 MHz, N_{SS} = 1

VHT-MCS Index	Modulation	R	N_{BPSCS}	N_{SD}	N_{SP}	N_{CBPS}	N_{DBPS}	N_{ES}	Data rate (Mb/s) 800 ns GI	Data rate (Mb/s) 400 ns GI (See NOTE)
0	BPSK	1/2	1	234	8	234	117	1	29.3	32.5
1	QPSK	1/2	2	234	8	468	234	1	58.5	65.0
2	QPSK	3/4	2	234	8	468	351	1	87.8	97.5
3	16-QAM	1/2	4	234	8	936	468	1	117.0	130.0
4	16-QAM	3/4	4	234	8	936	702	1	175.5	195.0
5	64-QAM	2/3	6	234	8	1404	936	1	234.0	260.0
6	64-QAM	3/4	6	234	8	1404	1053	1	263.3	292.5
7	64-QAM	5/6	6	234	8	1404	1170	1	292.5	325.0
8	256-QAM	3/4	8	234	8	1872	1404	1	351.0	390.0
9	256-QAM	5/6	8	234	8	1872	1560	1	390.0	433.3

NOTE—Support of 400 ns GI is optional on transmit and receive.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
frequency gap such that the one or more guard bands are at least partially filled with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform;	with at least some of the one or more data subcarriers using full spectral synthesis capability of a fast fourier transform or an inverse fast fourier transform. On information and belief, a 2 MHz frequency gap is present between the outer subcarriers of adjacent 20 MHz channels. In a 40 MHz bonded channel, this gap is partially filled with additional subcarriers.  Source: https://www.arubanetworks.com/assets/wp/WP_80211acInDepth.pdf.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**

Table 7-25f—Number of matrices and carrier grouping

BW	Grouping *Ng*	*Ns*	Carriers for which matrices are sent
20 MHz	1	56	All data and pilot carriers: –28, –27,…–2, –1, 1, 2,…27, 28
	2	30	–28,–26,–24,–22,–20,–18,–16,–14,–12,–10,–8,–6,–4,–2,–1, 1,3,5,7,9,11,13,15,17,19,21,23,25,27,28
	4	16	–28,–24,–20,–16,–12,–8,–4,–1,1,5,9,13,17,21,25,28
40 MHz	1	114	All data and pilot carriers: –58, –57, …, –3, –2, 2, 3,…, 57, 58
	2	58	–58,–56,–54,–52,–50,–48,–46,–44,–42,–40,–38,–36,–34,–32,–30, –28,–26,–24,–22,–20,–18,–16,–14,–12,–10,–8,–6,–4,–2, 2,4,6,8,10,12,14,16,18,20,22,24,26,28, 30,32,34,36,38,40,42,44,46,48,50,52,54,56,58
	4	30	–58,–54,–50,–46,–42,–38,–34,–30,–26,–22,–18,–14,–10,–6, –2, 2,6,10,14,18,22,26,30,34,38,42,46,50,54,58

Source: IEEE Standard 802.11n-2009 at 2356.

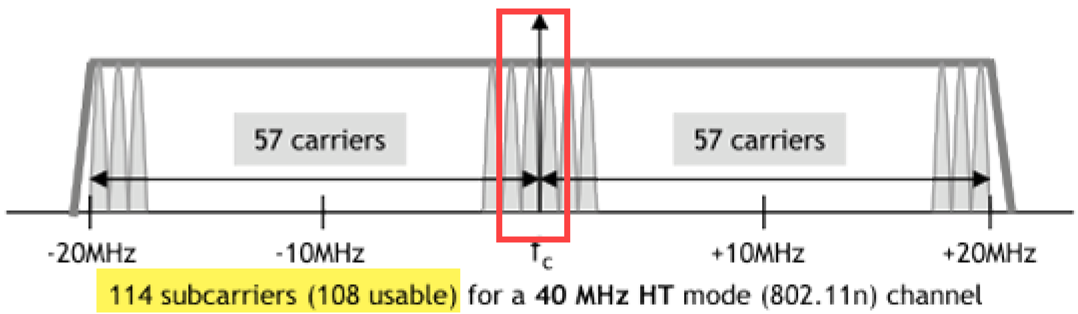
On information and belief, a 2 MHz frequency gap is present between the outer subcarriers of adjacent 20 MHz channels. In a 40 MHz bonded channel, this gap (6 sub carriers is partially filled with four additional subcarriers, corresponding to indexes –3,-2, +2 and +3. When two 20 MHz HT channels are bonded together, some of the formerly unused subcarriers at the bottom of the higher channel and at the top end of the lower channel can be used to transmit data. That is why the number of data subcarriers is slightly more than two times the 52 (=104) subcarriers in a 40 MHz channel, which is 108 as in table 19-6.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**

Table 20-5—Timing-related constants

Parameter	TXVECTOR CH_BANDWIDTH			
	NON_HT_CBW20	HT_CBW_20	HT_CBW40 or NON_HT_CBW40	
			HT format	MCS 32 and non-HT duplicate
N_{SD}: Number of complex data numbers	48	52	108	48
N_{SP}: Number of pilot values	4	4	6	4
N_{ST}: Total number of subcarriers See NOTE 1	52	56	114	104

Source: IEEE Standard 802.11n-2009 at Table 20-5.



Source: https://www.arubanetworks.com/assets/wp/WP_80211acInDepth.pdf.

Table 9-70—Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back

Channel Width	*Ng*	*Ns*	Subcarriers for which Compressed Feedback Beamforming Matrix subfield is sent: *scidx*(0), *scidx*(1), …, *scidx*(*Ns*-1)
20 MHz	1	52	–28, –27, –26, –25, –24, –23, –22, –20, –19, –18, –17, –16, –15, –14, –13, –12, –11, –10, –9, –8, –6, –5, –4, –3, –2, –1, 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28 NOTE—Pilot subcarriers (±21, ±7) and DC subcarrier (0) are skipped
	2	30	–28, –26, –24, –22, –20, –18, –16, –14, –12, –10, –8, –6, –4, –2, –1, 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
	4	16	–28, –24, –20, –16, –12, –8, –4, –1, 1, 4, 8, 12, 16, 20, 24, 28
40 MHz	1	108	–58, –57, –56, –55, –54, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –39, –38, –37, –36, –35, –34, –33, –32, –31, –30, –29, –28, –27, –26, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 54, 55, 56, 57, 58 NOTE—Pilot subcarriers (±53, ±25, ±11) and DC subcarriers (0, ±1) are skipped.
	2	58	–58, –56, –54, –52, –50, –48, –46, –44, –42, –40, –38, –36, –34, –32, –30, –28, –26, –24, -22, –20, –18, –16, –14, –12, –10, –8, –6, –4,–2, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58
	4	30	–58, –54, –50, –46, –42, –38, –34, –30, –26, –22, –18, –14, –10, –6,–2, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58
80 MHz	1	234	–122, –121, –120, –119, –118, –117, –116, –115, –114, –113, –112, –111, –110, –109, –108, –107, –106, –105, –104, –102, –101, –100, –99, –98, –97, –96, –95, –94, –93, –92, –91, –90, –89, –88, –87, –86, –85, –84, –83, –82, –81, –80, –79, –78, –77, –76, –74, –73, –72, –71, –70, –69, –68, –67, –66, –65, –64, –63, –62, –61, –60, –59, –58, –57, –56, –55, –54, –53, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –38, –37, –36, –35, –34, –33, –32, –31, –30, –29, –28, –27, –26, –25, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122 NOTE—Pilot subcarriers (±103, ±75, ±39, ±11) and DC subcarriers (0, ±1) are skipped.

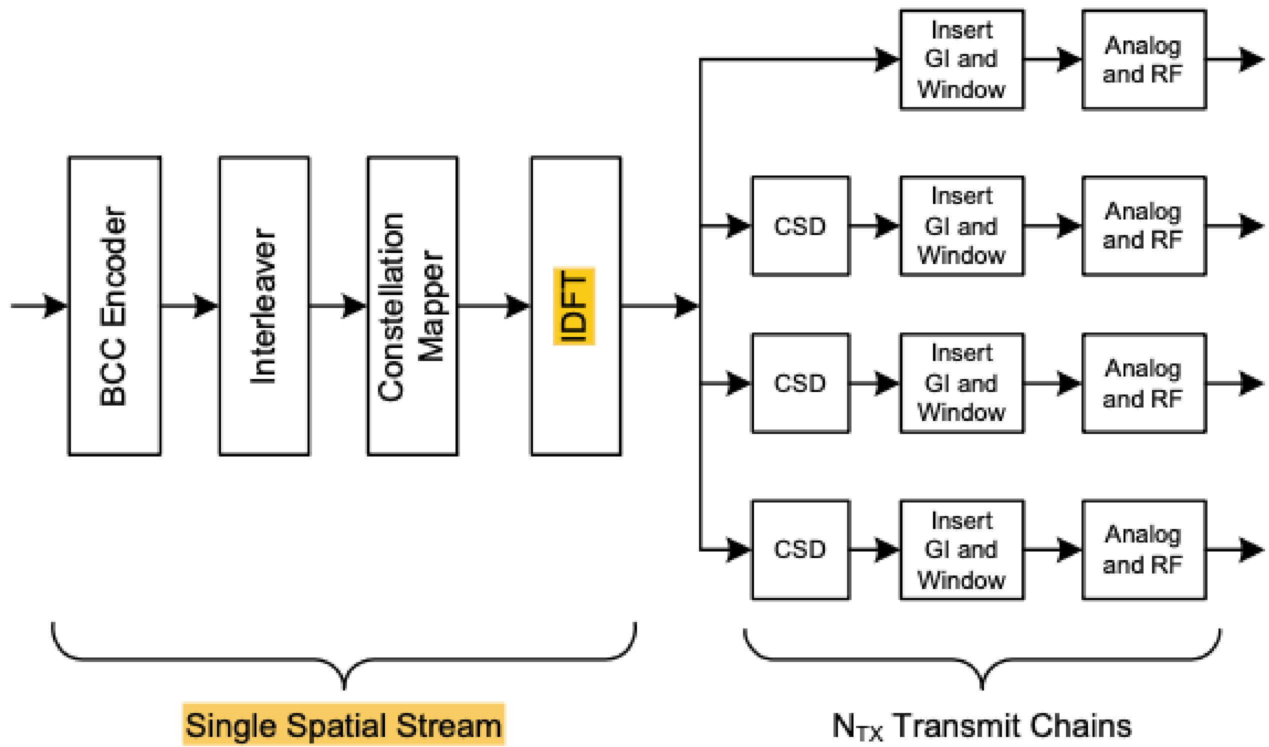
Source: IEEE Standard 802.11-2016 at 768.

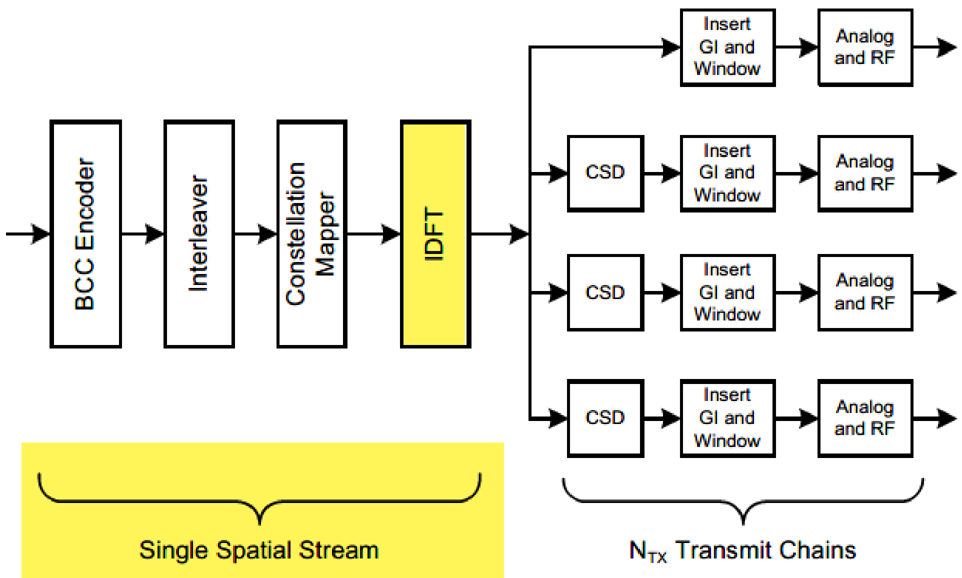
U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	(table continued below) Source: IEEE Standard 802.11n-2009 at 251. **4. Abbreviations and acronyms** IDFT inverse discrete Fourier transform Source: IEEE Standard 802.11n-2009 at 9.

CH_BANDWIDTH	FORMAT is HT_MF or HT_GF	Indicates whether the packet is transmitted using 40 MHz or 20 MHz channel width. Enumerated type: HT_CBW20 for 20 MHz and 40 MHz upper and 40 MHz lower modes HT_CBW40 for 40 MHz	Y	Y
	FORMAT is NON_HT	Enumerated type: NON_HT_CBW40 for non-HT duplicate format NON_HT_CBW20 for all other non-HT formats	Y	Y

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	20.3.7 Mathematical description of signals For the description of the convention on mathematical description of signals, see 17.3.2.4. In the case of either a 20 MHz non-HT format (TXVECTOR parameter FORMAT set to NON_HT, MODULATION parameter set to one of {DSSS-OFDM, ERP-OFDM, OFDM}) transmission or a 20 MHz HT format (TXVECTOR parameter FORMAT set to HT_MF or HT_GF, CH_BANDWIDTH set to HT_CBW_20) transmission, the channel is divided into 64 subcarriers. In the 20 MHz non-HT format, the signal is transmitted on subcarriers –26 to –1 and 1 to 26, with 0 being the center (dc) carrier. In the 20 MHz HT format, the signal is transmitted on subcarriers –28 to –1 and 1 to 28. In the case of the 40 MHz HT format, a 40 MHz channel is used. The channel is divided into 128 subcarriers. The signal is transmitted on subcarriers –58 to –2 and 2 to 58. Source: IEEE Standard 802.11n-2009 at 267. **19.3.7 Mathematical description of signals** For the description of the convention on mathematical description of signals, see 17.3.2.5. In the case of either a 20 MHz non-HT format (TXVECTOR parameter FORMAT equal to NON_HT, MODULATION parameter equal to one of {ERP-OFDM, OFDM}) transmission or a 20 MHz HT format (TXVECTOR parameter FORMAT equal to HT_MF or HT_GF, CH_BANDWIDTH equal to HT_CBW_20) transmission, the channel is divided into 64 subcarriers. In the 20 MHz non-HT format, the signal is transmitted on subcarriers –26 to –1 and 1 to 26, with 0 being the center (dc) carrier. In the 20 MHz HT format, the signal is transmitted on subcarriers –28 to –1 and 1 to 28. In the case of the 40 MHz HT format, a 40 MHz channel is used. The channel is divided into 128 subcarriers. The signal is transmitted on subcarriers –58 to –2 and 2 to 58. Source: IEEE Standard 802.11-2016 at 2356.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	On information and belief, the HT PHY uses a 128-point IDFT, usually implemented as an IFFT, to create the transmitted signal across the full 40 MHz signal spectrum. This process involves a fast fourier transform (FFT). **20.3.3 Transmitter block diagram** Figure 20-2 and Figure 20-3 show example transmitter block diagrams. In particular, Figure 20-2 shows the transmitter blocks used to generate the HT-SIG of the HT-mixed format PPDU. These transmitter blocks are also used to generate the non-HT portion of the HT-mixed format PPDU, except that the BCC encoder and interleaver are not used when generating the L-STF and L-LTFs. Figure 20-3 shows the transmitter blocks used to generate the Data field of the HT-mixed format and HT-greenfield format PPDUs. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HT-STF, HT-GF-STF, and HT-LTFs. The HT-greenfield format SIGNAL field is generated using the transmitter blocks shown in Figure 20-2, augmented by additional CSD and spatial mapping blocks.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	 **Figure 20-2—Transmitter block diagram 1** Source: IEEE Standard 802.11n-2009 at 261. On information and belief, IEEE 802.11ac infringes for the same reasons as 802.11n. *See supra*. *See also*: **19.3.3 Transmitter block diagram**

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	Figure 19-2 and Figure 19-3 show example transmitter block diagrams. In particular, Figure 19-2 shows the transmitter blocks used to generate the HT-SIG of the HT-mixed format PPDU. These transmitter blocks are also used to generate the non-HT portion of the HT-mixed format PPDU, except that the BCC encoder and interleaver are not used when generating the L-STF and L-LTFs. Figure 19-3 shows the transmitter blocks used to generate the Data field of the HT-mixed format and HT-greenfield format PPDUs. A subset of these transmitter blocks consisting of the constellation mapper and CSD blocks, as well as the blocks to the right of, and including, the spatial mapping block, are also used to generate the HT-STF, HT-GF-STF, and HT-LTFs. The HT-greenfield format SIGNAL field is generated using the transmitter blocks shown in Figure 19-2, augmented by additional CSD and spatial mapping blocks.  **Figure 19-2—Transmitter block diagram 1** Source: IEEE Standard 802.11-2016 at 2348-350.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	21.3.10.10 Pilot subcarriers In a 20 MHz transmission, four pilot tones shall be inserted in subcarriers $k \in \{-21, -7, 7, 21\}$. The pilot mapping P_n^k for subcarrier k for symbol n shall be as specified in Equation (21-91). $P_n^{\{-21,-7,7,21\}} = \{\Psi_{1,n \bmod 4}^{(1)}, \Psi_{1,(n+1) \bmod 4}^{(1)}, \Psi_{1,(n+2) \bmod 4}^{(1)}, \Psi_{1,(n+3) \bmod 4}^{(1)}\}$ $P_n^{k \notin \{-21,-7,7,21\}} = 0$ (21-91) where $\Psi_{1,m}^{(1)}$ is given by the $N_{STS} = 1$ row of Table 19-19 In a 40 MHz transmission, six pilot tones shall be inserted in subcarriers –53, –25, –11, 11, 25, and 53. The pilot mapping P_n^k for subcarrier k for symbol n shall be as specified in Equation (21-92). Source: IEEE Standard 802.11-2016 at 2574.

	Table 9-70—Subcarriers for which a Compressed Beamforming Feedback Matrix subfield is sent back

Channel Width	*Ng*	*Ns*	Subcarriers for which Compressed Feedback Beamforming Matrix subfield is sent: *scidx*(0), *scidx*(1), …, *scidx*(*Ns*-1)
20 MHz	1	52	–28, –27, –26, –25, –24, –23, –22, –20, –19, –18, –17, –16, –15, –14, –13, –12, –11, –10, –9, –8, –6, –5, –4, –3, –2, –1, 1, 2, 3, 4, 5, 6, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 22, 23, 24, 25, 26, 27, 28 NOTE—Pilot subcarriers (±21, ±7) and DC subcarrier (0) are skipped
	2	30	–28, –26, –24, –22, –20, –18, –16, –14, –12, –10, –8, –6, –4, –2, –1, 1, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28
	4	16	–28, –24, –20, –16, –12, –8, –4, –1, 1, 4, 8, 12, 16, 20, 24, 28
40 MHz	1	108	–58, –57, –56, –55, –54, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –39, –38, –37, –36, –35, –34, –33, –32, –31, –30, –29, –28, –27, –26, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 54, 55, 56, 57, 58 NOTE—Pilot subcarriers (±53, ±25, ±11) and DC subcarriers (0, ±1) are skipped.
	2	58	–58, –56, –54, –52, –50, –48, –46, –44, –42, –40, –38, –36, –34, –32, –30, –28, –26, –24, -22, –20, –18, –16, –14, –12, –10, –8, –6, –4,–2, 2, 4, 6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 38, 40, 42, 44, 46, 48, 50, 52, 54, 56, 58
	4	30	–58, –54, –50, –46, –42, –38, –34, –30, –26, –22, –18, –14, –10, –6,–2, 2, 6, 10, 14, 18, 22, 26, 30, 34, 38, 42, 46, 50, 54, 58
80 MHz	1	234	–122, –121, –120, –119, –118, –117, –116, –115, –114, –113, –112, –111, –110, –109, –108, –107, –106, –105, –104, –102, –101, –100, –99, –98, –97, –96, –95, –94, –93, –92, –91, –90, –89, –88, –87, –86, –85, –84, –83, –82, –81, –80, –79, –78, –77, –76, –74, –73, –72, –71, –70, –69, –68, –67, –66, –65, –64, –63, –62, –61, –60, –59, –58, –57, –56, –55, –54, –53, –52, –51, –50, –49, –48, –47, –46, –45, –44, –43, –42, –41, –40, –38, –37, –36, –35, –34, –33, –32, –31, –30, –29, –28, –27, –26, –25, –24, –23, –22, –21, –20, –19, –18, –17, –16, –15, –14, –13, –12, –10, –9, –8, –7, –6, –5, –4, –3, –2, 2, 3, 4, 5, 6, 7, 8, 9, 10, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55, 56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73, 74, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91, 92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 104, 105, 106, 107, 108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120, 121, 122 NOTE—Pilot subcarriers (±103, ±75, ±39, ±11) and DC subcarriers (0, ±1) are skipped.

Source: IEEE Standard 802.11-2016 at 768.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>
<table>
<tr><td rowspan="2">EXPANSION_MAT_TYPE</td><td>FORMAT is VHT and EXPANSION_MAT is present.</td><td>Set to COMPRESSED_SV</td><td>Y</td><td>N</td></tr>
<tr><td>Otherwise</td><td colspan="3">See corresponding entry in Table 19-1</td></tr>
<tr><td rowspan="2">EXPANSION_MAT</td><td>FORMAT is VHT</td><td>Contains a vector in the number of selected subcarriers containing feedback matrices as defined in 21.3.11.2 based on the channel measured during the training symbols of a previous VHT NDP PPDU.</td><td>MU</td><td>N</td></tr>
<tr><td>Otherwise</td><td colspan="3">See corresponding entry in Table 19-1</td></tr>
</table>
Source: IEEE Standard 802.11-2016 at 2501.
</td></tr>
<tr><td>[1.c] combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM); and</td><td>On information and belief, the Southwest Count 4 Systems and Services practice combining the first channel and the second channel using channel bonding with orthogonal frequency division multiplexing (OFDM).

On information and belief, in 40 MHz capable HT STA, both primary (“first”) and secondary (“second”) 20 MHz channels are combined by using channel bonding to give a wideband channel.</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**

	40MHZ OFDM 802.11N
	
	• 802.11n also introduced a 40 MHz channel, which combined two 20 MHz channels
	• The 40 MHz channel consists of 128 subcarriers:
	  • 128 subcarriers:
	    • 108 transmit data subcarriers
	    • 6 as pilot carriers
	    • 14 unused
	
	• When two 20 MHz HT channels are bonded together, some of the formerly unused subcarriers at the bottom of the higher channel and at the top end of the lower channel are able to be used to transmit data.
	• That is why the number of subcarriers is slightly more than two times the 56 subcarriers in a 20 MHz channel.
	• Each bonded channel consists of a primary and secondary 20 MHz channel.
	• The channels must be adjacent. A positive or negative offset indicates whether the secondary channel is the channel above or the channel below the primary channel. This is pictured in Figure 19.4.
	
	Source: https://dot11ap.wordpress.com/ht-channel-width-operation/.

<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>

20. High Throughput (HT) PHY specification

20.3.11.10 OFDM modulation

20.3.11.10.3 Transmission in 40 MHz HT format

For 40 MHz HT transmissions, the signal from transmit chain i_{TX} shall be as shown in Equation (20-59).

$$r_{HT-DATA}^{i_{TX}}(t) = \frac{1}{\sqrt{N_{STS} \cdot N_{HT-DATA}^{Tone}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} ([Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k, i_{STS}, n} + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \cdot \exp(j2\pi k\Delta_F(t - nT_{SYM} - T_{GI} - T_{CS}^{i_{STS}}))) \quad (20\text{-}59)$$

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</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	where z is 3 in an HT-mixed format packet and 2 in an HT-greenfield format packet p_n is defined in 17.3.5.9 $\tilde{D}_{k,i_{STS},n} = \begin{cases} 0, k = 0, \pm 1, \pm 11, \pm 25, \pm 53 \\ \tilde{d}_{M^r(k),i_{STS},n}, \text{otherwise} \end{cases}$ $M^r(k) = \begin{cases} k+58, -58 \le k \le -54 \\ k+57, -52 \le k \le -26 \\ k+56, -24 \le k \le -12 \\ k+55, -10 \le k \le -2 \\ k+52, 2 \le k \le 10 \\ k+51, 12 \le k \le 24 \\ k+50, 26 \le k \le 52 \\ k+49, 54 \le k \le 58 \end{cases}$ $P^k_{(i_{STS},n)}$ is defined in Equation (20-55) NOTE—The 90º rotation that is applied to the upper part of the 40 MHz channel is applied in the same way to the HT-STF, HT-LTF, and HT-SIG. The rotation applies to both pilots and the data in the upper part of the 40 MHz channel. Source: IEEE Standard 802.11n-2009 at 247, 298, 301-302. Improved OFDM and Channel Bonding

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	802.11n uses a more efficient OFDM modulation and can use 40 MHz channels. This more than doubles the data rate for 802.11n when compared to 20 MHz channels. When operating within a traditional 20 MHz channel, OFDM further slices the channel into 52 subcarriers (48 of which are used for carrying data). However, when 802.11n applies OFDM on a 40 MHz channel, the number of data-carrying subcarriers do not simply double to 96 sub-carriers. Instead, they actually more than double to 114 subcarriers, including pilots (which do not carry data). This allows 802.11n to deliver a 65 Mbps data rate (instead of 54 Mbps) per 20 MHz channel for a total of 135 Mbps on a 40 MHz channel when transmitting a single spatial data stream. When transmitting using 2 spatial streams on a 40 MHz channel, this data rate again doubles to 135 Mbps x 2 — 270 Mbps. Source: https://www.winncom.com/images/stories/Motorola_802.11nDEM_WP_v4_0209.pdf. **HT-OFDM** 802.11a and g used Orthogonal Frequency Division Multiplexing (OFDM) to transmit information. 802.11n continues to use OFDM but in a slightly different way. This new version is called HT-OFDM for High Throughput OFDM. How does OFDM works? The OFDM divides a channel into several subcarriers to carry information. For example, 802.11a and g use an OFDM that divides the 20MHz channels into 52 subcarriers. 48 of those are used for data transmission and 4 others are used for forward error correction. This configuration offers a data rates of 54 Mbps at best. When 802.11n uses 20MHz channels, HT-OFDM now offers 56 subcarriers. There are still 4 that are used for forward error correction and now 52 that are used for data transmission. This marginally increases the data rates to a maximum of 65 Mbps. This is when we use a single-transmitter radio. For two transmitters, the maximum data rates is 130 Mbps. Three transmitters provide a maximum data rates of 195 Mbps. The maximum four transmitters can deliver 260 Mbps. When a 40MHz channel is used, we get 108 subcarriers to transmit data information and 6 subcarriers for forward error correction. This way the channel is divided into 114 subcarriers. This provides a maximum data rates of 135 Mbps, 270 Mbps, 405 Mbps, and 540 Mbps for one through four transmitters, respectively.

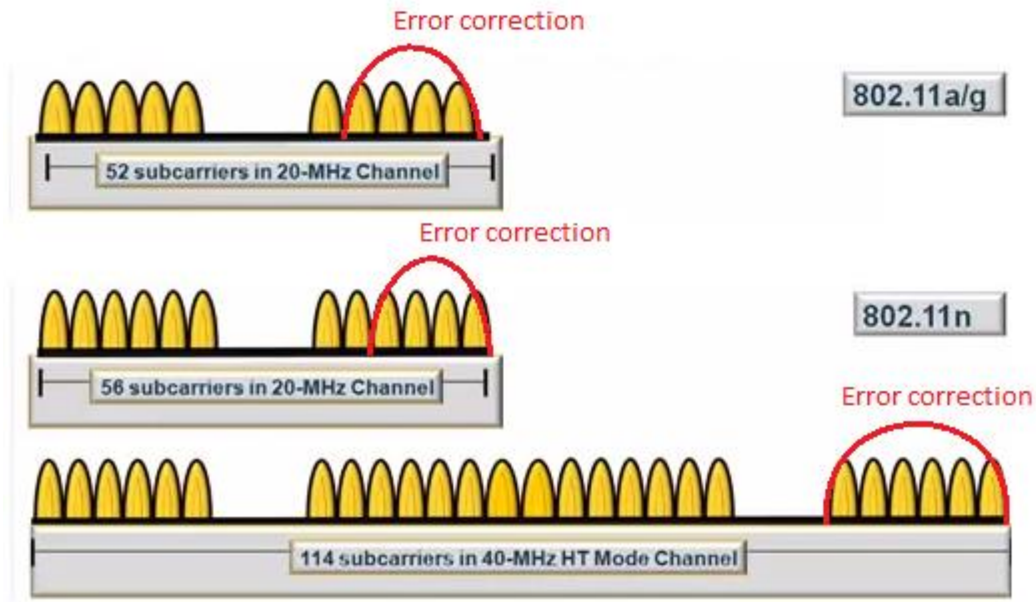
<table>
<tr><th colspan="2">U.S. Patent No. 8,027,326 (Claim 1)</th></tr>
<tr><th>Claim(s)</th><th>Example Southwest Count 4 Systems and Services</th></tr>
<tr><td></td><td>Source: https://www.gta.ufrj.br/ensino/eel879/trabalhos_vf_2014_2/remi/Physical%20Layer%20Improvements.html.


Figure 10: Number of subcarriers offered by OFDM
Source: https://www.gta.ufrj.br/ensino/eel879/trabalhos_vf_2014_2/remi/Physical%20Layer%20Improvements.html.
On information and belief, IEEE 802.11ac infringes for the same reasons as 802.11n. See supra. See also:</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	19. High-throughput (HT) PHY specification **19.3.11.11 OFDM modulation** **19.3.11.11.4 Transmission in 40 MHz HT format** For 40 MHz HT transmissions, the signal from transmit chain i_{TX} shall be as shown in Equation (19-59). $$r^{i_{TX}}_{HT-DATA}(t) = \frac{1}{\sqrt{N_{STS} \cdot N^{Tone}_{HT-DATA}}} \sum_{n=0}^{N_{SYM}-1} w_{T_{SYM}}(t - nT_{SYM}) \cdot \sum_{k=-N_{SR}}^{N_{SR}} \sum_{i_{STS}=1}^{N_{STS}} ([Q_k]_{i_{TX}, i_{STS}} (\tilde{D}_{k, i_{STS}, n} + p_{n+z} P^k_{(i_{STS}, n)}) \Upsilon_k \cdot \exp(j2\pi k \Delta_F (t - nT_{SYM} - T_{GI} - T^{i_{STS}}_{CS}))) \quad (19\text{-}59)$$ where z is 3 in an HT-mixed format packet and 2 in an HT-greenfield format packet p_n is defined in 17.3.5.10

<table>
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$$\tilde{D}_{k,i_{STS},n} = \begin{cases} 0, k = 0, \pm 1, \pm 11, \pm 25, \pm 53 \\ \tilde{d}_{M'(k), i_{STS}, n}, \text{ otherwise} \end{cases}$$

$$M'(k) = \begin{cases} k+58, -58 \le k \le -54 \\ k+57, -52 \le k \le -26 \\ k+56, -24 \le k \le -12 \\ k+55, -10 \le k \le -2 \\ k+52, 2 \le k \le 10 \\ k+51, 12 \le k \le 24 \\ k+50, 26 \le k \le 52 \\ k+49, 54 \le k \le 58 \end{cases}$$

$P^k_{(i_{STS},n)}$ is defined in Equation (19-55)

NOTE—The 90° rotation that is applied to the upper part of the 40 MHz channel is applied in the same way to the HT-STF, HT-LTF, and HT-SIG. The rotation applies to both pilots and the data in the upper part of the 40 MHz channel.

Source: IEEE Standard 802.11-2016 at 2334, 2387, 2390-2391.
</td></tr>
<tr><td>[1.d] transmitting data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel to a receiver.</td><td>On information and belief, the Southwest Count 4 Systems and Services practice transmitting data subcarriers occupying the first channel, the second channel, and the frequency gap in parallel to a receiver.

On information and belief, subcarriers occupying both channels and the partially-filled frequency gap are transmitted in parallel.

20.3.4 Overview of the PPDU encoding process
</td></tr>
</table>

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	o) Determine whether 20 MHz or 40 MHz operation is to be used from the CH_BANDWIDTH parameter of the TXVECTOR. Specifically, when CH_BANDWIDTH is HT_CBW20 or NON_HT_CBW20, 20 MHz operation is to be used. When CH_BANDWIDTH is HT_CBW40 or NON_HT_CBW40, 40 MHz operation is to be used. For 20 MHz operation (with the exception of non-HT formats), insert four subcarriers as pilots into positions –21, –7, 7, and 21. The total number of the subcarriers, N_{ST}, is 56. For 40 MHz operation (with the exception of MCS 32 and non-HT duplicate format), insert six subcarriers as pilots into positions –53, –25, –11, 11, 25, and 53, resulting in a total of N_{ST} = 114 subcarriers. See 20.3.11.10.4 for pilot locations when using MCS 32 and 20.3.11.11 for pilot locations when using non-HT duplicate format. The pilots are modulated using a pseudo-random cover sequence. Refer to 20.3.11.9 for details. For 40 MHz operation, apply a +90 degree phase shift to the complex value in each OFDM subcarrier with an index greater than 0, as described in 20.3.11.10.3, 20.3.11.10.4, and 20.3.11.11. p) Map each of the complex numbers in each of the N_{ST} subcarriers in each of the OFDM symbols in each of the N_{STS} space-time streams to the N_{TX} transmit chain inputs. For direct-mapped operation, $N_{TX} = N_{STS}$, and there is a one-to-one correspondence between space-time streams and transmit chains. In this case, the OFDM symbols associated with each space-time stream are also associated with the corresponding transmit chain. Otherwise, a spatial mapping matrix associated with each OFDM subcarrier, as indicated by the EXPANSION_MAT parameter of the TXVECTOR, is used to perform a linear transformation on the vector of N_{STS} complex numbers associated with each subcarrier in each OFDM symbol. This spatial mapping matrix maps the vector of N_{STS} complex numbers in each subcarrier into a vector of N_{TX} complex numbers in each subcarrier. The sequence of N_{ST} complex numbers associated with each transmit chain (where each of the N_{ST} complex numbers is taken from the same position in the N_{TX} vector of complex numbers across the N_{ST} subcarriers associated with an OFDM symbol) constitutes an OFDM symbol associated with the corresponding transmit chain. For details, see 20.3.11.10. Spatial mapping matrices may include cyclic shifts, as described in 20.3.11.10.1.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	t) Up-convert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 20.3.7 for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if ASEL is applied. Source: IEEE Standard 802.11n-2009 at 262-264. On information and belief, IEEE 802.11ac infringes for the same reasons as 802.11n. *See supra*. *See also*: **19.3.4 Overview of the PPDU encoding process**

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	o) Determine whether 20 MHz or 40 MHz operation is to be used from the CH_BANDWIDTH parameter of the TXVECTOR. Specifically, when CH_BANDWIDTH is HT_CBW20 or NON_HT_CBW20, 20 MHz operation is to be used. When CH_BANDWIDTH is HT_CBW40 or NON_HT_CBW40, 40 MHz operation is to be used. For 20 MHz operation (with the exception of non-HT formats), insert four subcarriers as pilots into positions –21, –7, 7, and 21. The total number of the subcarriers, N_{ST}, is 56. For 40 MHz operation (with the exception of MCS 32 and non-HT duplicate format), insert six subcarriers as pilots into positions –53, –25, –11, 11, 25, and 53, resulting in a total of N_{ST} = 114 subcarriers. See 19.3.11.11.5 for pilot locations when using MCS 32 and 19.3.11.12 for pilot locations when using non-HT duplicate format. The pilots are modulated using a pseudorandom cover sequence. Refer to 19.3.11.10 for details. For 40 MHz operation, apply a +90° phase shift to the complex value in each OFDM subcarrier with an index greater than 0, as described in 19.3.11.11.4, 19.3.11.11.5, and 19.3.11.12. p) Map each of the complex numbers in each of the N_{ST} subcarriers in each of the OFDM symbols in each of the N_{STS} space-time streams to the N_{TX} transmit chain inputs. For direct-mapped operation, $N_{TX} = N_{STS}$, and there is a one-to-one correspondence between space-time streams and transmit chains. In this case, the OFDM symbols associated with each space-time stream are also associated with the corresponding transmit chain. Otherwise, a spatial mapping matrix associated with each OFDM subcarrier, as indicated by the EXPANSION_MAT parameter of the TXVECTOR, is used to perform a linear transformation on the vector of N_{STS} complex numbers associated with each subcarrier in each OFDM symbol. This spatial mapping matrix maps the vector of N_{STS} complex numbers in each subcarrier into a vector of N_{TX} complex numbers in each subcarrier. The sequence of N_{ST} complex numbers associated with each transmit chain (where each of the N_{ST} complex numbers is taken from the same position in the N_{TX} vector of complex numbers across the N_{ST} subcarriers associated with an OFDM symbol) constitutes an OFDM symbol associated with the corresponding transmit chain. For details, see 19.3.11.11. Spatial mapping matrices may include cyclic shifts, as described in 19.3.11.11.2.

U.S. Patent No. 8,027,326 (Claim 1)	
Claim(s)	**Example Southwest Count 4 Systems and Services**
	t) Upconvert the resulting complex baseband waveform associated with each transmit chain to an RF signal according to the center frequency of the desired channel and transmit. Refer to 19.3.7 for details. The transmit chains are connected to antenna elements according to ANTENNA_SET of the TXVECTOR if ASEL is applied. Source: IEEE Standard 802.11-2016 at 2349-2353.